**REMARKS:**

Claims 1-15 remain in the application.

Claims 1 and 6 have been amended to highlight the fact that the invention includes a **precision rectifier circuit**.

The Examiner has rejected claim 11 as being fully anticipated by U.S. Patent 5,486,815 to **Wagner**. Claims 1-2, 4 and 14-15 are also rejected as being obvious from a combination of **Wagner** in view of U.S. Patent 4,620,141 to McCumber et al.

Claim 3 is rejected as obvious from a combination of **Wagner**, **McCumber** and the U.S. Patent 5,859,536 to **Stockton**.

Claim 5 is rejected as obvious from a combination of **Wagner** and **Howarth**.

Claim 12 is rejected as obvious from a combination of **Wagner** and **Stockton**.

In order to address each of these rejections and hopefully demonstrate to the Examiner that the claims are both novel and unobvious over the references taken separately or in combination, the applicants position will first be summarized and then each of the Examiner's comments and observations discussed in detail.

## I. SUMMARY

It is believed that the Examiner has not fully appreciated the RF amplification detection scheme upon which the claimed invention is based. The Examiner has interpreted use of an RC network connected to the sensor in the **Wagner** reference as applicable for "impedance matching" or comprised of resistance and reactive impedance active at the excitation frequency. The subject and teaching of **Wagner's** RC network is, however, only a low frequency averaging network, as reactance of the capacitor used is virtually zero at the RF frequency utilized for excitation of the sensor, and does not

anticipate claim 11.

The Examiner's combinations of **Wagner** with the various secondary references, are all based upon variants of this theme and, it is sincerely believed, do not in fact reach the now claimed invention in an obvious manner.

## II. RC NETWORK INTERPRETATION

The present application illustrates use of a phase shift network for improvement of measurement range, comprised of R8 and C5 in FIG. 2 of the application, for example. **Wagner** does show an RC network connected across the sensor, from the center detection pad to ground (outside border of the sensor). It is **not** connected between the driven and receiving elements of the sensor, as in the present case, and utilizes a capacitor with very low reactance at the sensor frequency, and thus is very long in time constant. **Wagner's** use of the same involves development of a DC voltage which is amplified and applied to a timer which maintains the unit in the on-state apparently for a time dependent upon signal development from the sensor (i.e. active use of the device). The Examiner stresses in many instances that the claimed use of a "reactive impedance network" is taught by **Wagner** and is thus not patentable. However, both the network connection scheme differences and the clearly delineated differences in purposes are outstanding. From the **Wagner** reference, one cannot infer knowledge or description of an RC network for phase shift purposes at the sensor operating frequency.

In the present case, the network is connected between the excitation and receiving elements of the sensor (neither network connection is grounded as in **Wagner**). It supplies a small amount of AC bias to the center sensing pad, but it is of a leading phase nature due to the parallel RC structure. Since R4 in the circuits of FIGs. 1 and 2 of the

present application is high in value and only intended to provide a DC return for operational amplifier U2 non-inverting input, the RF signal induced in sensing pad 14 would ordinarily be in phase with that provided for excitation at driven ring 12. This is so because the two are capacitively coupled without any significant shunt resistance to AC ground (R4 not withstanding as it is large in value). The combination of R8 and C5 form a lead network, whose effect is to provide phase lead for sensor pad 14 when only minimal external coupling (i.e. low sample moisture content) is present in the sample being tested. The phase lead disappears as capacitance between ring 12 and pad 14 as capacitance between the two increases (i.e. when measuring a moist sample). Thus, moisture measurement range is extended because two factors contribute to amplitude change at the sensor: change in capacitive coupling between ring 12 and pad 14, and phase change between the excitation source and sensor receiving element (pad 14). Thus the AC voltage change at sensor pad 14 in the presence of a measured moisture bearing sample is greater than can be provided by change in capacitive coupling between ring 12 and pad 14 alone. This is not taught or suggested by **Wagner** or any other cited reference.

## III. POSSIBLE PRIOR ART DISCLOSURE OF PRECISION RECTIFIER IN MOISTURE MEASUREMENT APPLICATION

US Patent 4,259,632 to **Ahtiainen** (1978), which was cited as of interest only, does make reference to the term "ideal rectifier" in his specification, which is equivalent to the generally accepted terminology "precision rectifier" used in the present application. However, the reference makes no reference to clamping the amplifier output in the opposite direction, thereby limiting the frequency at which the circuit can be used. The clamping diode is shown by **Wagner**, but without the forward direction diode in the

feedback loop, and thus **Wagner** does not show, and cannot suggest precision rectifier circuitry. The **Ahtiainen** "ideal rectifier" contains several flaws preventing its functioning in the manner presented and intended by the claimed invention:

• First is the absence of an inverse shunt diode to prevent the amplifier from saturating on negative-going output excursions. As widely known, bipolar transistors used in amplifiers and elsewhere exhibit so-called "storage time" effects when subjected to operation in saturation. Storage time results from finite time required for charge carrier recombination, and is manifested as a time delay from the time amplifier input signal reversal indicates that output signal change should occur until it actually takes place. This limits the bandwidth and fidelity of the recovered signal.

• No attempt is made to ameliorate effects of stray capacitance possessed by the diode, which at higher frequencies may dominate performance to the point where precision rectification will, in fact, not occur. In the extreme, the operational amplifier and diode combination will perform as a voltage follower if followed by a high impedance load, as in feeding the non-inverting input of another operational amplifier. In the present disclosure, R3 has been added for the very purpose of providing a relatively low impedance load for the diode, for the very reason described. In addition, R1 and R2 appear in parallel with R3, further contributing to loading of diode D1 (C1 is a DC blocking capacitor, very low in reactance at the operating frequency).

• **Ahtiainen** shows no DC return for the inverting input of his operational amplifier (anode connection of diode), and is therefore unworkable in the general case. It would be workable only for operational amplifiers with relatively substantial inward-flowing bias current, and could not work with amplifiers such as the widely used LM324 whose bias current is outward-flowing. In the present application, R2 provides the stated DC return,

either through conduction of D1 or through resistance of R3 (see the figure in **Ahtiainen**).

• The **Ahtiainen** circuit can only be connected to a load which sinks current, again due to absence of load impedance for the diode. If connected to a circuit which sources current (such as the non-inverting input of an LM324 operational amplifier), output of the Ahtiainen "ideal rectifier" will climb to a high positive voltage and remain at that value.

## IV. WITH REFERENCE TO EACH SECTION OF THE ACTION

On page 2, paragraph 2 of the Office Action, the third bullet note refers to a **precision** rectifier. The word "precision" is not used by **Wagner**, nor is the concept tought of suggested by this reference.

Any diode taken alone is **not a "precision" rectifier.** The circuit illustrated by **Wagner** uses the referenced diode in **open loop** fashion. A **precision** rectifier is a **feedback circuit of which the diode is only one part,** usually utilizing an operational amplifier as in our case. Because **Wagner** operates the diode as an open loop device, its forward voltage drop, which changes with respect to temperature, is responsible for moisture reading errors. Incorporation of the diode within the feedback loop of an operational amplifier **nullifies forward voltage drops associated with diodes, virtually completely** on the condition that bandwidth of the operational amplifier is sufficient for the task, and on the condition that diode reverse recovery time is very small (assured in our case by use of a Schottky diode). Compensation in like manner **cannot** be done by another diode, regardless of thermal coupling **because the forward voltage drop is a function of the instantaneous current through the diode.** Further, the ohmic component of apparent diode "resistance" is a function of instantaneous forward current. Therefore, the claimed invention in claim 11 of the present application is completely

different from **Wagner** in the stated way. Coupling of an oscillator to a sensor is know. Even use of an inductor (commonly referred to as an "RF choke") for DC return is also prior art. The novelty of the claimed invention, however, is in the combination of a correctly defined and illustrated precision rectifier with the existing oscillator and sensor combination.

Referring now to page 3, paragraph 4 of the Action, the first two bullet notes can be found in prior art. The third bullet note cannot be found, however.

Two schematic drawings are found in the **Wagner** patent, one identified as prior art and the other as an embodiment of the **Wagner** invention. Neither illustrated "an operational amplifier...having one input 3 connected to the pad,..." Therefore, this is not an accurate statement of **Wagner's** teaching.

The fourth bullet note on page 3 of the Action appears to completely ignore the principle of a precision rectifier circuit, and, instead, addresses the unrelated attempt at temperature compensation of the first diode by use of a second diode. Referring to the last bullet note on page 3: Diode D2 **does not operate in any fashion as described by the Examiner.**

D2 is part of a "keep-alive" circuit for the oscillator and operates by rectifying the pulsed output of IC1, pin 1. Output of that amplifier is pulsed because it is operated **open loop (no feedback).** Rather, **Wagner** provides "psuedo" temperature compensation of signal rectification diode 142 by nearly ***DC operation of*** diode 170, both in the same package for thermal tracking. However, 170 cannot accurately compensate all non-idealities of 142 because 142 rectifies the RF signal at detector pad 120, where the rectified signal is filtered by C6. Therefore the conduction angle of 142 is short with correspondingly higher and quite variable currents which cannot be compensated

accurately by essentially DC operation of 170. All such consideration pales in any event when compared to the fundamental issue, that of the **precision rectifier circuit** of the present invention as compared with attempts at use of a second diode for temperature compensation of a first, where current vs. time considerations for each differ as described.

Please see the following section for a definition and specific characteristics of a precision rectifier circuit.

On page 4 of the Action, the third bullet note, features of **McCumber** are discussed. In **McCumber**, diode 176 **is most definitely not in a feedback loop of an operational amplifier and is therefore not part of a precision rectifier circuit.** In the same manner as **Wagner**, signal rectification by the diode is subject to all manner of errors due to forward voltage drop, temperature inducted effects of the same. Diode 144 is indeed in the feedback loop of operational amplifier 134 but it is clearly used for **feedback voltage *clamping*** purposes. This is commonly implemented because driving operational amplifier outputs into saturation invokes a requirement for recovery time for return to normal operation. This is commonly understood by those skilled in the art of carrier-recombination storage effects in bipolar transistors. Discussion about diode 144 not withstanding, FIGs. 1 and 2 of the present application illustrate feedback resistor R2 and resistor R1 (AC coupled to ground) implementing a feedback network for nullification of non-ideal characteristics of D1 by incorporation of D1 within the feedback loop. This is not the case regarding diode 176 in **McCumber**, allowing thermal effects and other non-ideal aspects of diode 176 operation to permit error-inducing operation. Unlike **Wagner**, there is no attempt to temperature compensate non-idealities arising from such operation, as flawed as such attempts utilizing a separate diode may be. The only means of effectively nullifying diode non-idealities is by use of a precision rectifier circuit as described above,

relevant to the present application and claimed invention.

On page 4 of the Action, the Examners comments further on **Wagner** teaching. It is believed that the Examiner has miss-stated the purpose of R12 and C7 in **Wagner** in these comments. In addition the Examiner's conclusion is flawed in that the pad and ring are **not** connected by those two components. Rather, those components connect between the detector pad and the **common or ground** element of the sensor. In any event, those components provide **averaging of the DC level at detector pad 120,** as may be gleaned from the high resistance of R12 and compared with the low capacitive reactance of C7 at the operating frequency. In the present application, resistive-capacitive network R8-C5 is connected between the center pad and receiving ring for **modification of the RF baseline seen by receiving pad 14.** Further, the claimed components are in parallel, not series. C2, in FIG. 1 of teh application, is a DC blocking capacitor, and does not enter into resistive-reactive impedance modification between excited ring 12 and receiving pad 14.

At the bottom of page 4 of the Action, the Examiner also does not correctly charaterize the workings of **Wagner**. The amplifier mentioned is single ended, not differential amplifier. More importantly, the signal applied to pin 12 is not RF, but DC as described above due to low reactance of C7 compared with resistance of R12. It is this amplifier that drives the meter, 192 after DC amplification. The average DC level at pin 12 **increases** with moisture content due to a decrease in **average DC level** at pad 120 as moisture content increases. That occurs as a consequence of greater coupling between ring 214 and pad 120, since the dielectric constant of water is high, about 80. Again, C7 and R12 form a DC averaging network, not an RF phase shift or “impedance” network. There is no “cancellation" of part of the sensor signal by the stated amplifier. None of the foregoing is relevant, however, because it completely ignores the accepted definition and

our application of a **precision rectifier circuit.**

Referring not to page 5 of the Action, third bullet note, the referenced **McCumber** diode is indeed in the feedback loop of operational amplifier but it is clearly used for **feedback voltage *clamping*** purposes to avoid amplifier saturation as already stated. Interconnection of diodes or other elements between terminals of an operational amplifier does not define the function or structure of the diode unless the representation is clear as to the purposes, not evident in the case of **McCumber**. In the claimed invention, advantage is taken of nullification of diode forward voltage drop by the feedback diode, not an obvious possibility in **McCumber**. A difference in diode interconnection between operational amplifier terminals, the diode, and the opamp following the stage under discussion shows this to be true. **McCumber** cannot near-ideal rectification performance with his circuit.

The Examiner's conclusion at the top of page 6 of the Action is groundless. The purpose of diode interconnections referenced in the former statements are not correct and the holding that ends "...as taught by **McCumber**, in the moisture sensing apparatus of **Wagner**, in order to provide stability of the signal" is not suported by any obvious combination of the references. This ignores the nature of a precision rectifier and the claimed invention.

Refering now to the bottom of page 6 of the Action, the purpose of the reactive impedance members was discussed earlier in these remarks. Values of the resistor and capacitor associated with the reactance network is greatly skewed from what would be required for reactive modification of the RF signal to or from the sensor. Clearly, when values of R and C are examined, the corner frequency of the pair is such that it reduces to nothing more than a poorly damped low frequency, low pass filter, as part of a network

which with aid of timer circuitry, ultimately keeps the oscillator active for a period of some tens of seconds.

At the top of page 7 of the Action, **Stockton** is discussed. **Stockton** shows a combination of resistance and capacitance connected to a sensor pad. Again the Examiner refers to that as a matter of impedance matching. The present application has nothing to do with impedance matching. The core substance of the claimed invention is **precision rectification circuitry** of the sensor signal. The invention does a **phase shift** using reactive components but not impedance matching.

The Examiner mentions **Stockton** but gives no details regarding relevance and then reiterates the fact that **Wagner** discloses a sensor pad and ring arrangement and then states that **Howarth** discloses use of sensor electrodes with no angular corners.

What is believed to be most distinctive about the present invention is the **precision rectifier circuitry** mainly, and further in a dependant manner, the combination with the sensor and phase shifting circuitry. Concerning the latter, the Examiner cites **Wagner** as using an RC network in the sensor circuitry, but in **Wagner's** case it serves the purpose of a low pass filter **by virtue of the time constant of the components used**, without any evidence that **Wagner** ever foresaw, or that the person of ordinary skill in this art would find obvious, the value of phase shifting for signal detection enhancement **using reactive** and resistive **components which present definable phase shift rather than simple low pass filtering at the operating frequency.**

Turning to the Action at pages 8-10, again the same material is presented by the Examiner without considering the precision rectifier circuit features which are now claimed, or the difference between an RC network used for phase shifting as opposed to low pass

filtering as previously claimed.

The combination of references would not suggest that sensor technology of the type used in the present application should be combined with precision rectification circuitry or phase shift circuitry for signal enhancement.

On page 11 of the Action reactive impedance matching is mentioned. The claimed invention performs no impedance matching. The subject of precision rectification is different.

On page 12, the Examiner refers to the **Ahtiainen** patent as relevant background art. **Ahtiainen** suggests a very rudimentary implementation of a precision rectifier which is stated to operate at low frequencies due to shortcomings of operational amplifiers then available. However, the cited reference makes no reference to clamping the amplifier output in the opposite direction, thereby limiting the frequency at which the circuit can be used. A clamping diode is shown by **Wagner**, but without the forward direction diode in the feedback loop. Nonetheless, the elements of a precision rectifier in combination with an oscillator and sensor can be independently found in piecemeal fashion in the prior art, but no obvious combination would yeild the claimed invention.

## V. CONCLUSIONS

Use of an RC network as described by **Wagner** is very different from the claimed use of the same in the present application. **Wagner** uses an RC network as a low pass filter, connected from the sensed signal electrode of the sensor to ground, for determination of DC component, further stated to be so in their specification and by observation of the high value capacitor (0.01µF) and consequent low reactance of the same at sensor excitation frequency. The Examiner also refers to use of RC networks for

"impedance matching." Since resistors introduce loss, and since impedance matching is virtually always defined as a means of insuring maximum signal or power transfer between circuit segments, RC networks are rarely if ever used for RF impedance matching. In any event, the invention here uses R8 and C5 for development of phase shift, to assist in dynamic range of signal production vs. sample moisture content. **Wagner** never states or gives any indication of anticipating RF phase shift as a means of performance enhancement.

For the foregoing reasons the claims are believed to be in condition for allowance, and favorable action is respectfully requested. .

The Examiner is respectfully urged to telephone the undersigned if any matters remain which can be treated by telephone interview in the interest of reaching a conclusion to the prosecution of this case.

Favorable action is respectfully requested.

Respectfully submitted,

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